SENSORY EVALUATION OF BEEF STEAKS STORED IN MA COMBINATIONS OF CO, CO_2, N_2 AND O_2

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Introduction

Studies have demonstrated that in steaks of beef loin, sensory properties like tenderness and juiciness decrease during storage in a modified atmosphere containing high oxygen and that warmed over flavour (WOF) may increase (Seideman *et al.*, 1979, Tørngren, 2003; Clausen, 2004; Sørheim *et al.*, 2004). Case ready meat packaging is a fast growing segment, where it is important to use packing that preserves quality during storage. MAP (modified atmosphere packaging) with high O_2 also increases the amount of oxymyoglobin, which gives rise to a well-done appearance at lower temperatures (Hunt *et al.*, 1999). An alternative to high O_2 MAP is a combination of CO_2, N_2 and CO. CO_2 is added to the gas mixture because of its antimicrobiological properties (Jakobsen and Bertelsen, 2002) and increases the shelf life. CO_2 has, however, shown adverse effect on beef steak quality, where more than 20% increase the development of pores and fissures after cooking caused by rapid release of CO_2 from the meat (Bruce *et al.*, 1996; Penny, 1999). Increased CO_2 may also lead to snug down (low pressure) if CO_2 is absorbed in the meat. N_2 is an inert gas, but beef meat will appear purple (deoxymyoglobin), if O_2 is completely excluded from the gas mixture, or brown (metmyoglobin), if a little O_2 (½-1%) is left in the pack. Small amounts of CO (0.4%) gives the meat the desirable shiny red colour corresponding to meat exposed to O_2. Adding 0.3-0.5% CO in a gas mixture is estimated not to constitute any health risk by the European Commission (2001) but it is presently not on the list of accepted gas combinations as it is in the USA. In this study, the effect of using CO in a packing gas on the sensory quality of steaks is compared to several other packing alternatives, to obtain a full picture of the available options for retail packing of beef.

Materials and Methods

Source of meat: 24 M. *longissimus dorsi* (LD) from twelve dairy cows and heifers (27-54 months; 232-300 kg; low voltage electrically stimulated and chilled at 10°C the first 12 hours after stunning, stored at 2°C for 3 days; pH 5.5-5.6) were cut in three and vacuum packed. After 14 days, the six samples from the same animal were randomised with respect to packaging gas: ① 60% CO_2 / 40% N_2, ② 60% CO_2 / 39.6% N_2 / 0.4% CO, ③ 30% CO_2 / 70% N_2, ④ 30% CO_2 / 69.6% N_2 / 0.4% CO, ⑤ 30% CO_2 / 70% O_2 and ⑥ Vacuum skinpackaging. The LD was sliced into 22mm thick steaks, weighed and packed and stored at 2°C for six days. After storage the steaks were weighed again to calculate drip loss during storage.

Packaging materials: Vacuum skinpacking (an upper co-extruded film and a bottom semi-rigid film in the form of a tray): Max. O_2 permeability (upper film and bottom): 2 $cm^3/m^2/$ x d x bar (Cryovac, Sealed Air Corporation). Vacuum: 5-10 mbar (Multivac packing machine). MAP: Tray (13x18x4 cm) covered with transparent film (TOPSEAL™PP MAP AF 57), O_2 permeability: <100 $cm^3/m^2/d$, bar.

Colour: Measured immediately after the removal of the wrap (Minolta (L*, a*, b*).

Cooking and sensory evaluation: Steaks were equilibrated at room temperature (approx. 20°C) to an internal temperature of max. 15°C prior to cooking on a preheated frying pan (155°C), turned every 2 minutes until an internal temperature of 62±1°C had been reached. Steaks were weighed before and after cooking to calculate cooking loss. Steaks were cut and served in pieces of 2½ x 3cm. Samples were evaluated by 9 trained assessors using a 15-point non-structured line (0=slight and 15= intense). The attributes comprised tenderness, juiciness, Warmed Over Flavour (WOF), meat-flavour and doneness (internal colour).

Statistics: Data were analysed in an analysis of variance model (mixed procedure, SAS version 8.2). Fixed effects in the model were main effects.

Results and Discussion

Results of of the study are shown in Table 1.

Meat Colour: CO packed steaks were higher in a* (redness) and lower in b* (yellowness) than O_2 packed steaks, but we consider the differences to be small and of no concern to the consumer. MA packed steaks (without O_2 and CO) were lower in a* and higher in b* and L* (lightness) than vacuum-skin packed. The explanation is probably development of metmyoglobin despite the low O_2 in the package (<0.1%), but O_2 permeability was rather high.

Drip loss: Drip loss was higher for vacuum-skinpacked steaks (1%), than MAP (irrespective of gas combination; 0.6-0.7%).

Eating quality: Addition of CO did not affect eating quality or the internal colour (doneness) of the cooked steaks. Clausen and Madsen (2005) found that CO did not affect eating quality of beef patties but the internal colour (after cooking to 76°C) appeared less done. Beef steaks packed with high CO_2 (60%) were less juicy than steaks packed with low CO_2 (30%). Clausen and Madsen (2005) have also shown that high CO_2 decreases juiciness. High CO_2 increased

doneness after cooking compared to packs with low CO_2.
Steaks packed in O_2 were less tender than vacuum skinpacked steaks. They had less meat flavour, developed extreme WOF and looked well done although the internal temperature was only 62°C (premature browning). Several investigations have shown that O_2 is detrimental to the eating quality and causes premature browning (Tørngren, 2003, Clausen, 2004, Sørheim 2004).
Cooking loss: Cooking loss was lower for O_2 MAP than high CO_2 MAP.

Table 1: Mean drip loss, colour (Minolta) and sensory score*

Packaging atmosphere (measured **)	Drip loss	Colour L*	Colour a*	Colour b*	Tender-ness	Juici-ness	WOF	Meat flavour	Done-ness	Cook-ing loss
31% CO_2 / 69% N_2	0.6^{b}	36.4^{b}	12.6^{d}	6.3^{c}	9.0	9.1^{a}	1.5^{b}	7.8^{a}	5.6^{c}	12.8^{ab}
28% CO_2 / 71.6% N_2 / 0.4% CO	0.6^{b}	37.7^{a}	24.9^{a}	8.5^{b}	8.9	9.0^{a}	1.2^{b}	7.6^{a}	5.7^{c}	14.4^{ab}
54% CO_2 / 46% N_2	0.7^{b}	36.1^{b}	12.0^{d}	5.3^{d}	8.8	8.2^{ab}	1.5^{b}	7.8^{a}	6.9^{bc}	15.6^{a}
58% CO_2 / 41.6% N_2 / 0,4% CO	0.6^{b}	37.9^{a}	24.7^{a}	8.2^{b}	8.7	7.7^{b}	2.1^{b}	7.1^{a}	7.2^{b}	14.8^{a}
30% CO_2 / 70% O_2	$0,7^{b}$	38.6^{a}	23.7^{b}	11.8^{a}	8.5^{b}	8.5^{ab}	11.9^{a}	4.5^{b}	12.3^{a}	12.6^{b}
Vacuum-skinpackaging	1.0^{a}	33.9^{c}	17.2^{c}	3.5^{e}	9.6^{a}	9.0^{a}	1.2^{b}	7.8^{a}	6.3^{bc}	14.1^{ab}
Significance level	P<0,001	P<0,001	P<0,001	P<0,001		P<0,05	P<0,001	P<0,001	P<0,001	P<0,05

*(a non-structured line scale, anchored to the extremes; 0=slight, 15=intense) steaks of beef loin stored in 6 different atmospheres (n=12)
** the delivered gas combinations was not exactly as specified

Conclusions
CO packed steaks appeared shiny red, and differed only sligthly in a* and b* values from O_2 packed steaks. CO_2/N_2 packed steaks differed in L*, a* and b* compared to vacuum packed steaks, probably due to metmyoglobin development. CO did not affect the eating quality of beef steaks. High CO_2 (60%) packaging resulted in steaks that were less juicy than low CO_2 packed. O_2 packed steaks were less tender and scored lower in meat flavour and considerably higher in WOF and well done appearance than vacuum-skin packed steaks.

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